GameTools
Advanced Tools for Developing Highly Realistic Computer Games

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Abstract

The game industry has a huge impact on computer graphics research and education. Many new research papers mention computer games as one of the main application areas. However, there is still a lack of knowledge transfer from academia towards the actual game industry. The gap between the presentation of new ideas to the academic community and their actual applicability in games remains significant, and is often too large for small and medium-sized SMEs to bridge. Creating a channel with a steady flow of information from academia to industry represents a new challenge, both for research groups and game companies.
We will present in this talk the GameTools Project, an European Union (EU) project from the 6th Framework Programme, that tries to answer this challenge by bringing together leading European computer graphic experts from universities in Austria, France, Hungary and Spain with European industrial partners from the fields of computer game development and virtual reality to create next generation real time 3D libraries.

1. Introduction

Recent improvements in graphics hardware and CPU power have allowed computer games to implement more and more realistic computer graphics techniques. This encounter between a massive consumer market and the computer graphics technology is significantly boosting both fields. Computer graphics play a key role in providing computer games with the ever-increasing realism demanded by game players. Visibility, geometry, and lighting are three of the main areas involved in the development of a computer game. Hence, this project aims at developing new tools that will dramatically increase the realism and visual quality of computer games in these three key areas in modern computer graphics:

- High quality, automated visibility for dynamic scenes, exploiting modern computer graphics hardware, will enable the rendering of larger, more impressive scenery without costly human pre-processing.
- Intelligent geometry complexity reduction will allow for unprecedented detail in the rendering of highly complex objects such as plants.
- Real-time global illumination will give previously unseen visual quality in dynamic lighting.

For videogames, this allows for larger, more realistic and impressive worlds to be presented to the player, which leads to a stronger emotional immersion in the game and therefore a better game experience.
For non-gaming high-end 3D applications, such as interactive architectural walkthroughs, the GameTools library allows for a highly realistic visual representation, previously not possible in real time.
The tools are being developed around the software that sits at the core of a computer game, the 3D engine. To achieve its goals, this project has brought together European computer graphics research groups and game companies. As computer games techniques are very close to the ones used in the fields of Virtual Reality and simulation, two companies from these sectors also take part in the project. The modules developed by the research groups are validated and tested by the game companies, and integrated into their in-house rendering systems to provide demonstrators showing the viability of the developed methods.
Although the game development industry in Europe is facing rising revenues, most European game developers are facing severe problems. Computer game companies in Europe are usually SMEs which are continually under threat because of the dominant position of North American and multinational companies. Also due to the high-risk nature of game development, shortage of funding for research and stringent deadlines in the sector, knowledge transfer from academia to industry is extremely slow. The GameTools project was originally addressed to improve this knowledge transfer.
This paper is organised as follows. Section 2 introduces the consortium history, the partners, some management issues, and the Special Interest Group. We outline the results obtained so far in section 3 and finally, section 4 provides our conclusions.

2. GameTools Project

This section presents the different main aspects of the GameTools project. First, the history before this Project was accepted by the EC is explained. Then, we present the different partners who are participating in the project, followed by the way we are managing it. Next subsection presents the Special Interest Group. Finally, we present the results we expect to obtain from the project.

2.1. Project History

GameTools project was accepted only after the third application. The first proposal was rejected mainly because there were too many partners involved, and there was a lack of focus in the project (the scope was too broad). Another reason was that there were few industrial partners in the proposed consortium.
However the European Commission was still interested in the project, so a second version of the project was presented following their recommendations. This second proposal was again rejected because still there were few industrial partners in the consortium. The main reason why it was so difficult to get this kind of partners involved in the project is that computer games companies are used to deal with projects of less than 2 years long, while GameTools project was longer.
Therefore, an important effort was invested in trying to find these industrial partners. Gedas and DLE (see section 2.2) were incorporated thanks to their relationship with the UdG and the Project Coordinator. AIJU also made an important contribution, and thanks to his contacts, Sektor4 and Infowerk were also incorporated to the project. This time, GameTools was accepted by the European Commission, obtaining a very good evaluation.

2.2. Partners

The consortium of GameTools is made up of 12 organisations. Six of them are Universities, namely Universitat de Girona (UdG), Universitat Jaume 1er (UJI), Universitat Politècnica de València (UPV), Budapest University of Technology and Economics (BUTE), Vienna University of Technology (VUT) and Université de Limoges (Unilim). The seventh organisation is AIJU, which is a non-profit organisation that provides 450 European toy industries with scientific and technical services. The last five are the companies described as follows:

- PGM Trading (PGM) is based in Austria, and has extensive experience in 3D graphics and AI programming. Its approach is blending cutting edge technology innovations, outstanding artwork and novel game play to produce groundbreaking games.
- Digital Legends Entertainment (DLE) is a Barcelona based company, aiming at developing video games and associated technologies for worldwide markets.
- Sektor4 is a Danish company which provides services, in the form of products and projects, in which 3D graphical content plays a central role, such as interactive 3D product visualisation software to be used on web pages, or virtual 3D learning / educational games.
- Infowerk Softwareentwicklung (Infowerk) is an Austrian company specialised in the development of multimedia based e-learning and e-business solutions.
- Gedas Iberia (Gedas) is a company based near Barcelona, who belongs to the Volkswagen group and has big experience in Information Technologies, especially in Virtual Reality (VR) solutions, Computer Assisted Design (CAD), Computer Assisted Manufacturing (CAM) and Computer Assisted Engineering (CAE).

GameTools is coordinated by the Girona Graphics Group (GGG) from the UdG. This group has expertise in advanced computer graphics techniques and has actively cooperated with computer games companies. It has also a track record of successful cooperation with the other entities of the consortium. As it has been explained before, and is shown in Figure 2.1, there are 6 universities, 5 companies and AIJU.

The role each partner plays in GameTools strongly depends on the group it belongs to:

- Universities are in charge of conducting the R&D on visibility, geometry and illumination that will lead to the resulting plug-ins necessary to improve the realism and visual quality of computer games, VR systems and graphical simulators
- Companies will develop several demonstrators that will proof the increase in realism and visual quality in industrial and commercial environments. The plug-ins will be integrated and tested in the companies own products
- AIJU is an excellent communication channel, and so it will be mainly involved in dissemination activities

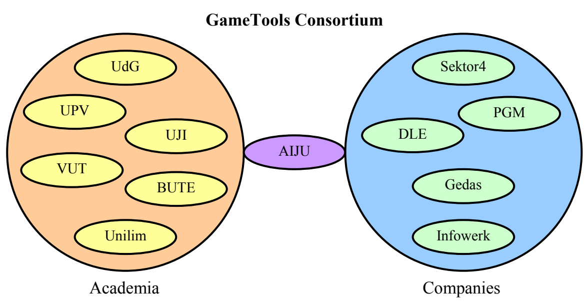

Figure 2.1: GameTools Consortium Schema

2.3. Management

GameTools is managed using the structure shown in Figure 3.2. The main component is the Project Management Committee (PMC). PMC is chaired by the Project Coordinator, who is in charge of the technical and scientific issues, and the Project Manager, who is in charge of the administrative, financial and legal execution of the project. Each non-coordinating partner is represented by its Partner Leader. The PMC is in charge of assessing and monitoring the progress and results of the project, taking the necessary corrective actions when necessary.
Every Partner Leader is responsible for the proper execution of the tasks his organisation has been assigned. He has to ensure that the work packages his organisation leads produce the deliverables in due time and according to the terms stated in the work plan.
The PMC has the Project Management Office (PMO) at his disposal to execute the management tasks, housed at the Coordinator home (UdG). It is in charge of providing the overall administrative and economic management support required by the project. The project website, the internal repositories for documentation and software, and the mailing lists for internal communication are located and maintained by the PMO.
Last but not least, there are two important roles in the project: the Community Manager is in charge of the Special Interest Group which is described in Section 3.4, and the Exploitation Manager is responsible for the production of the dissemination and exploitation plans. As this project deals with Computer Graphics, which is a highly dynamic field, he is also in charge of monitoring the market conditions in order to provide feedback to the consortium to perform fine tuning of the commercial objectives.

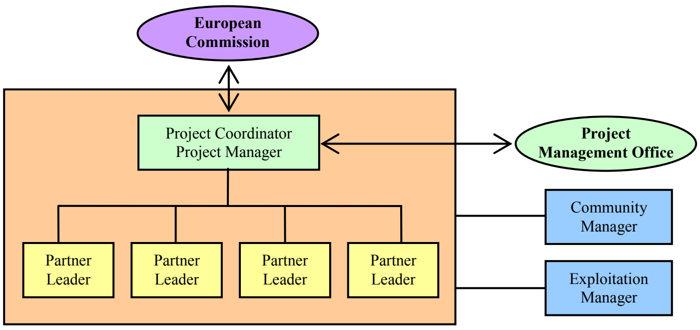

Figure 2.2: Project Management Structure

2.4. Special Interest Group

One of the GameTools goals is to strengthen the European software industry working with Real time 3D graphics. This means game development companies, including computer games (PC) and videogames for different platforms such as Xbox, PS2, Xbox360 or PS3. Also Visualisation companies, including architecture or product visualisation, and other fields like 3D simulation of Virtual Reality.
To reach this goal, the GameTools SIG gives its members preliminary access to the project technology and C++ source code developed during the course of GameTools. This allows them to:

- Access the technology at the earliest time possible
- Integrate the technology while it is being developed, allowing for faster time to market
- Immediately use the parts of the GameTools results which will be completed before the end of the project
- Develop their 3D code so that it is compatible with the GameTools libraries
- Give feedback to the GameTools developers about possible integration issues
- Get support from the developers
- In general influence the GameTools project development process

SIG members do not have to supply anything (source code, etc) back to the GameTools project. Any company developing software in the European Union can apply for membership in the GameTools SIG. SIG is administered by the Community Manager, who can be reached through the GameTools website [1].

3. Expected Technological Results

We present here the technological expected results in the different aspects of GameTools, namely visibility, geometry and illumination, together with some preliminary results. [2][3][4]

3.1. Visibility

The visibility work package consists of two main modules: the online visibility culling module and the visibility pre-processing module.
The online module operates in runtime to quickly cull occluded objects given a particular viewpoint and a viewing direction. In order to achieve this goal we exploit recent support of graphics hardware for occlusion queries. We have developed a new occlusion culling algorithm which provides efficient scheduling of the occlusion queries. Large regions of similar visibility are culled early by using a hierarchy. To eliminate CPU stalls and GPU starvation, we exploit temporal and spatial coherence and schedule the occlusion queries using a priority queue. To reduce unnecessary queries, we pull up and push down visibility information in the hierarchy. The resulting algorithm provides about twofold speedup over previous state of the art. More details can be found at http://www.cg.tuwien.ac.at/research/vr/chcull/.

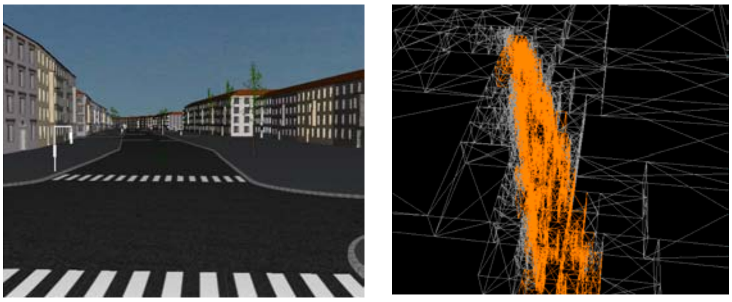

Figure 3.1 (left): Snapshot of a city scene where online visibility is computed. (Right) Visibility classification of the hierarchy nodes in the city scene. The orange nodes were found visible; all the other depicted nodes are invisible.

The pre-processing module subdivides the space of all possible viewpoints and viewing directions into view cells and determines a potential visible set (PVS) for the view cells. Note that our module aims at handling more general scenes and providing more accurate PVSs than the Quake style PVS computation does. We have developed and tested an exact analytic algorithm suitable for PVS computation in 2.5D urban scenes. We currently work on an exact PVS algorithm for arbitrary 3D scenes. The algorithm is based on hierarchical subdivision of line space maintained by a 5D BSP tree. The tree represents sets of occluded and unoccluded lines with respect to the view cell and the polygons in the scene. We design a methodology which makes the theoretical concept practical for arbitrary, large, 3D scenes. In order to limit the possible growth in memory complexity and robustness problems of the method, the transformation to line space and further higher dimensional subdivision is localized: we use a subdivision of the whole line space into shafts, in order to limit the visibility complexity within each shaft. This allows us to balance the memory consumption of the method for the speed, i.e. subdivision into a larger number of smaller sub-problems.

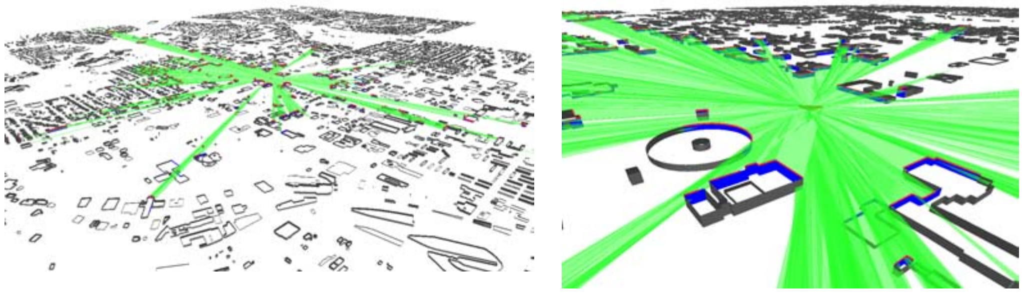

Figure 3.2: Visualization of the PVS for a given view cell in a model of Atlanta.

3.2. Geometry

The goal of the geometry work package is the development of a set of modules to handle objects with dynamic geometry, adapting its level of detail to the application requirements. The level of detail is continuously adjusted avoiding the popping artefacts that appear in discrete multi-resolution models.

We can consider this work package as a compound of four modules: the stripification module, the simplification module, the construction module and the library that will interact with Ogre. In this way, simplification, stripification and the construction of the model will be done in a pre-process stage, and the related modules will be independent of the Ogre engine.

The multi-resolution model we are developing improves existing models in terms of storage and visualization cost. This model is wholly based on triangle strips, which leads to an important reduction in storage and rendering costs. But this model is not suitable for trees and plants, as it won't work properly with the crown of trees which is composed of a set of isolated polygons. This is the reason why we need a special multi-resolution model for trees and plants, with different algorithms for the simplification, the constructor and the library.

At the moment, we are working in parallel in the development of the modules for general meshes and for plants and trees. We have preliminary versions of the independent modules, including simple algorithms while we are investigating new methods for both the simplification and stripification modules. We also have a preliminary version of the final libraries that will enable the integration of these multi-resolution models inside Ogre. These initial versions of the libraries are useful for testing and permits capturing images directly from the engine, like the ones shown en Figure 3.3.

Figure 3.3: happy_buddha model shown within an Ogre scene.

3.3. Illumination

In illumination workpackage we develop real-time methods for games that can provide highly realistic illumination. In order to achieve this goal, the latest capabilities of the graphics hardware (GPU) are exploited. The development efforts go into different directions aiming at modules computing different illumination phenomena and applying different models. Then these models can be built into games separately or can be combined together in a game engine. In the following paragraphs we review the main modules.

Approximate ray tracing module delivers ray tracing effects, such as reflections, refractions and caustics on few hundred frames per second due to their GPU implementation. The method is based on special environment mapping when the distance information is also stored in environment map texels, from which localized reflections can be obtained.

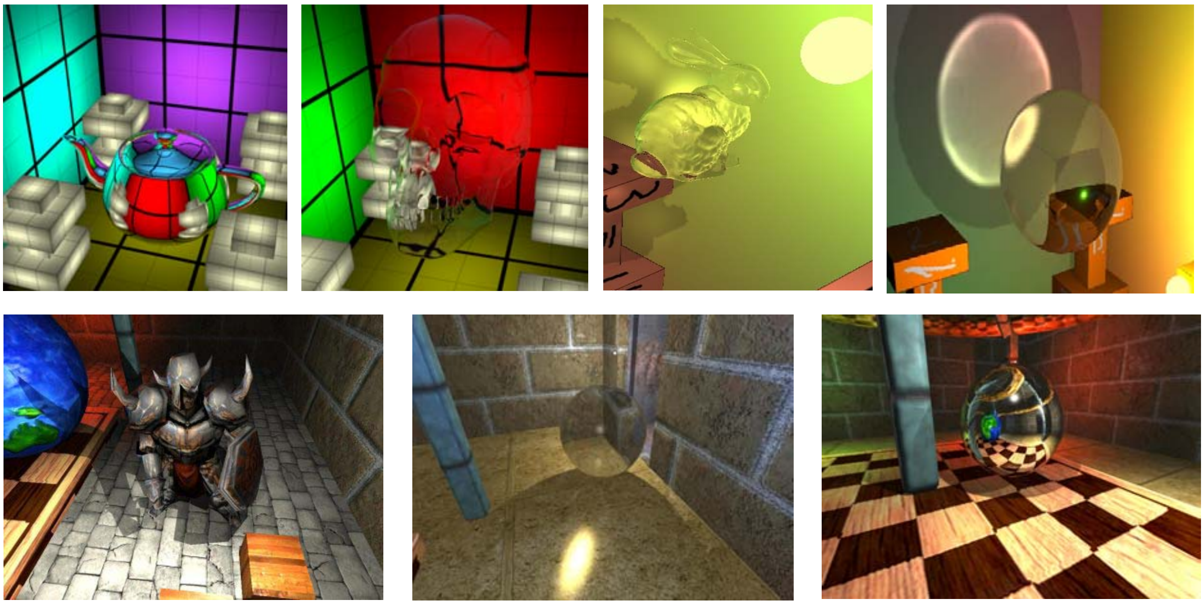

Figure 3.4: Approximate ray tracing images rendered on 50..200 FPS.

Pre-computed global illumination module handles large static environments that are illuminated by dynamic light sources and rendered from a moving camera. The light paths responsible for indirect global illumination are partially pre-computed and stored in textures allowing interactive light and camera animation and the incorporation of shadows of dynamic occluders.

Figure 3.5: Comparison of classical local illumination (upper half of the left and middle images) and the global illumination of the new method (lower part of the left and middle images and the right image of a cave).

Parcipating media module computes volumetric effects, such as clouds, smoke, fire, etc. We consider not only realistic lighting, but also the inclusion of conventional 3D models inside the volume.

Figure 3.6: 3D objects in dynamically animated and illuminated clouds (left and middle) and a physically accurate global illumination rendering of a cloud (right) at 40 FPS.

Obscurances module simulates global illumination effects at a much lower cost. The cost reduction comes from considering only the local neighborhood of each point when its indirect illumination is computed.

Figure 3.7: Complex 3D models rendered with the obscurances method.

Image based lighting module computes the effects of environment lighting taking into account the distribution of the sky illumination and also shadowing effects in real time.

Figure 3.8: Image based lighting with shadowing in real time.

Image based rendering module attacks complex scenes by replacing complex geometry by images (billboards). Our goal is to develop methods that get the enormous speed increase due to the replacement of a complex geometry by a single image, but without the obvious artifacts, for example, without losing the parallax effects

Figure 3.9: A forest of trees maintaining the visual accuracy for different viewpoints and rendered at 30 FPS.

4. Conclusions

We have presented here GameTools, an EU project from the 6th Framework Programme. This project deals with computer games; not with the task of creating any specific game, but with the development of new tools to increase the realism and visual quality of computer games. Up to now, there has been an important gap between the new ideas provided by the academic community and their applicability in video games. This is mainly due to the fact that computer game companies in Europe are usually SMEs who cannot compete with United States companies in the same conditions. This makes them have a really short funding in research and development, and in this way is very difficult for them to bridge the technology transfer gap and include new ideas from universities in their commercial products.

GameTools has been created to fight this problem. The consortium is formed by 6 universities which have a recognised expertise in computer graphics, 5 companies who deal with video games and VR applications and finally AIJU, which is a non-profit organisation that provides European toy companies with scientific and technical services, and which acts as a bridge between academia and companies.

GameTools will develop the new tools around the software that sits at the core of a computer game, the 3D engine (a public domain engine, OGRE is used for this). The project will work in three different areas involved in the development of a computer game: visibility, geometry and illumination.

Once the development of the different modules is finished, they will be integrated into commercial games, VR and simulation software owned by the consortium companies.

A special interest group has been created so that European Companies can have preferent access to GameTools technology.

References

1. GameTools project website: www.gametools.org
2. Szirmay-Kalos László, Antal György and Mateu Sbert. “Go with the Winners Strategy in Path Tracing”. Journal of WSCG, 2005.
3. Stefan Jeschke, Michael Wimmer, Heidrun Schumann, Werner Purgathofer. “Automatic Impostor Placement for Guaranteed Frame Rates and Low Memory Requirements”. In Proceedings of ACM SIGGRAPH 2005 Symposium on Interactive 3D Graphics and Games. April 2005.

4. Pascual Castelló, José Francisco Ramos, Miguel Chover, "A Comparative Study of Acceleration Techniques for Geometric Visualization" Fourth International Workshop on Computer Graphics and Geometric Modeling, CGGM 2005.